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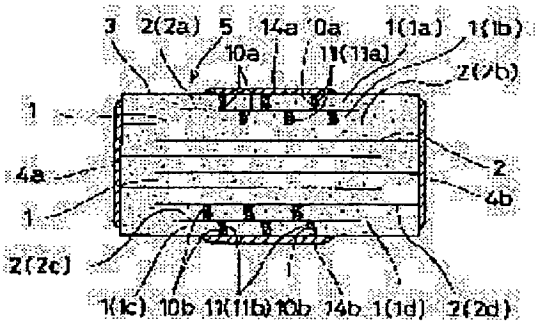
(54) CONNECTION STRUCTURE OF INTERNAL AND EXTERNAL ELECTRODES OF LAMINATION-TYPE PIEZOELECTRIC BODY ELEMENT

(57)Abstract:
PURPOSE: To positively connect an external electrode which is formed on upper and lower surfaces and an internal electrode provided between piezoelectric body layers without losing the flatness of the upper and lower surfaces of a lamination-type piezoelectric body element.
CONSTITUTION: Pores 10a and 10b are formed at piezoelectric body layers 1a, 1b, 1c, and 1d near external electrodes 14a and 14b on upper and lower surfaces and at the same time conductive materials 11a and 11b are impregnated inside them and then each internal electrode 2 and external electrodes 14a and 14b on the upper and lower surfaces continue via the conductive materials 11a and 11b and external electrodes 4a and 4b formed on a side surface.



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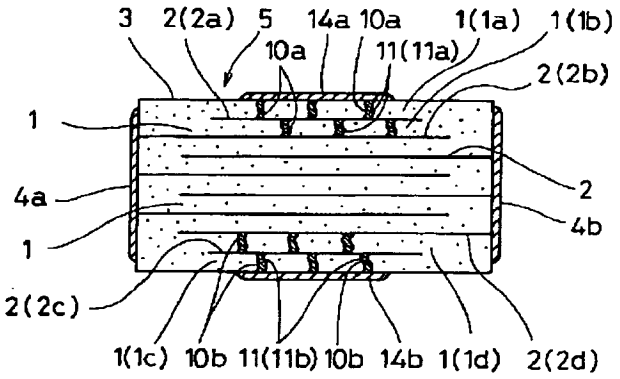
(54)【発明の名称】積層型圧電体素子の内部電極と外部電極の接続構造

(57)【要約】

【目的】　積層型圧電体素子の上・下面の平坦性を損うことなく、上・下面に形成された外部電極と圧電体層間に配設された内部電極とを確実に接続する。

【構成】　上・下面の外部電極１４ａ，１４ｂに近い圧電体層１ａ，１ｂ，１ｃ，１ｄにポア１０ａ，１０ｂを形成するとともに、その内部に導電材料１１ａ，１１ｂを浸透させ、該導電材料１１ａ，１１ｂ及び側面に形成された外部電極４ａ，４ｂを介して、各内部電極２と上・下面の外部電極１４ａ，１４ｂとを導通させる。



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【特許請求の範囲】

【請求項１】　複数の圧電体層と、圧電体層間に配設された内部電極と、内部電極が引き出された側面、及び上・下面に形成された外部電極とを備えてなる積層型圧電体素子の、前記内部電極を前記上・下面の外部電極の少なくとも一方に接続するための接続構造であって、

上・下面の外部電極に近い圧電体層にポアを形成するとともに、その内部に導電材料を浸透させ、該導電材料及び側面に形成された外部電極を介して、各内部電極と上・下面の外部電極とを導通させるようにしたことを特徴とする積層型圧電体素子の内部電極と外部電極の接続構造。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】この発明は、積層型圧電体素子に関し、詳しくは、上・下面に形成された外部電極と圧電体層間に配設された内部電極とを電気的に接続するための接続構造に関する。

【０００２】

【従来の技術】圧電体を利用した積層型圧電アクチュエータとしては、例えば、図４に示すように、複数の圧電体層５１の間に部分電極構造を有する内部電極５２を配設するとともに、圧電体層５１と内部電極５２からなる積層体５３の、内部電極５２が引き出された側面からその上・下面に回り込むように外部電極５４を配設してなる積層型圧電体素子５５を、金属板５６を介して複数個積み重ね、所定の金属板５６をリード線５７により接続するとともに、ばね圧により固定した構造の積層型圧電アクチュエータが提案されている。

【０００３】なお、上記の積層型圧電アクチュエータを構成する積層型圧電体素子５５においては、内部電極５２は、図５に示すように、一層おきに逆側の側面の外部電極５４（図４）と導通するように交互に逆側の端部に引き出されている。

【０００４】また、外部電極５４としては、内部電極５２との導通の確実性を考慮して厚膜電極が用いられている。

【０００５】そして、この積層型圧電アクチュエータにおいては、各積層型圧電体素子５５の間に挿入された金属板５６と各積層型圧電体素子５５の上・下面にまで回り込むように形成された外部電極５４とを接触させるだけで、内部電極５２と金属板５６との導通が得られるという長所がある。

【０００６】

【発明が解決しようとする課題】しかし、上記の積層型圧電アクチュエータにおいては、積層型圧電体素子５５の外部電極５４が積層体５３の側面から上・下面にまで回り込むように形成されているため、図６に示すように、積層体５３の角部において外部電極５４に盛上り（こぶ）５８が発生し、積層型圧電体素子５５の上・下

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面の平坦性が損われる。そのため、複数の積層型圧電体素子５５を金属板５６を介して積み重ねた場合に、積重ね状態（連結固定状態）が不安定になり、確実に固定することができなかったり、積層型圧電アクチュエータとして使用した場合に、外力によって破壊が生じたりするというような問題点がある。

【０００７】この発明は、上記問題点を解決するものであり、積層型圧電体素子の上・下面の平坦性を損うことなく、上・下面に形成された外部電極と圧電体層間に配設された内部電極とを確実に接続することが可能な積層型圧電体素子の内部電極と外部電極の接続構造を提供することを目的とする。

【０００８】

【課題を解決するための手段】上記目的を達成するために、この発明の積層型圧電体素子の内部電極と外部電極の接続構造は、複数の圧電体層と、圧電体層間に配設された内部電極と、内部電極が引き出された側面、及び上・下面に形成された外部電極とを備えてなる積層型圧電体素子の、前記内部電極を前記上・下面の外部電極の少なくとも一方に接続するための接続構造であって、上・下面の外部電極に近い圧電体層にポアを形成するとともに、その内部に導電材料を浸透させ、該導電材料及び側面に形成された外部電極を介して、各内部電極と上・下面の外部電極とを導通させるようにしたことを特徴とする。

【０００９】なお、この発明は、内部電極を上・下面の外部電極の両方に接続する場合に限らず、内部電極を上・下面の外部電極のいずれか一方にのみ接続する場合の接続構造をも含むものである。

【００１０】この発明の積層型圧電体素子の内部電極と外部電極の接続構造において、所定の圧電体層に選択的にポアを形成するための方法としては、例えば、ポアを形成することを意図しない圧電体層のグリーンシートには脱泡処理を行う一方、ポアを形成すべき圧電体層のグリーンシートに対しては脱泡処理を行わなかったり、あるいは、積極的に気泡を混入させる処理を施したりすることによりポアを形成する方法を用いることが可能である。

【００１１】また、ポアに導電材料を浸透させる方法としては、上記のようにしてポアを形成した圧電体層のグリーンシートに導電ペーストを塗布し、焼成することにより、圧電体層のポア内に導電材料を浸透させる方法などを用いることができる。

【００１２】なお、所定の圧電体層に選択的にポアを形成するとともに、ポア内に導電材料を浸透させる方法は、上記の方法に限られるものではなく、さらに他の方法を用いることも可能である。

【００１３】

【作用】この発明の積層型圧電体素子の内部電極と外部電極の接続構造においては、外部電極に近い位置にある

圧電体層に、選択的にポアを形成するとともに、その内部に導電材料を浸透させることにより、該圧電体層に導電性が付与される。したがって、従来の積層型圧電体素子のように、側面に形成された外部電極（各内部電極と導通している）を、その上・下面にまで回り込ませることなく、側面に形成された外部電極と、導電性が付与された圧電体層を介して、各内部電極と上・下面の外部電極とを導通させることが可能になる。

【００１４】それゆえ、従来の積層型圧電体素子のように、積層体の側面に形成された外部電極を上・下面にまで回り込ませた場合に見られるような、積層体の角部における外部電極（厚膜電極）の盛上り（こぶ）の発生を防止して、積層型圧電体素子の上・下面の平坦性を確保しつつ、各内部電極と上・下面の外部電極とを確実に導通させることが可能になる。

【００１５】

【実施例】以下、この発明の実施例を示してその特徴とするところをさらに詳しく説明する。図１は、この発明の一実施例にかかる接続構造により内部電極と外部電極を接続した積層型圧電体素子を示す断面図である。

【００１６】この積層型圧電体素子５は、積層された複数の圧電体層（チタン酸ジルコン酸鉛系材料からなる圧電体層）１と、複数の圧電体層１間に配設された内部電極２と、複数の圧電体層１と内部電極２とを備えてなる積層体３の内部電極２が引き出された側面に形成された外部電極４ａ，４ｂと、積層体３の上・下面に形成された外部電極１４ａ，１４ｂとを備えて構成されている。

【００１７】そして、上・下面の外部電極１４ａ，１４ｂに近い位置にある圧電体層１（すなわち最上層１（１ａ）及びその次の圧電体層１（１ｂ）及び最下層の圧電体層１（１ｃ）及びその次の圧電体層１（１ｄ））の中央部にはポア１０ａ，１０ｂが形成されているとともに、その内部には、導電材料（導通用電極）１１（１１ａ，１１ｂ）が配設されている。なお、この実施例の積層型圧電体素子５においては、上・下面の外部電極１４ａ，１４ｂに最も近い内部電極２（２ａ），２（２ｃ）は、側面の外部電極４ａ，４ｂとは導通せず、浮いた状態で配設されており、中継電極として機能するように構成されている。

【００１８】そして、ポア１０ａ内の導電材料１１（１１ａ）及び中継電極として機能する内部電極２ａを介して、最上層から２番目の内部電極２ｂが上面の外部電極１４ａと導通するとともに、一方の側面（左側の側面）に引き出されて外部電極４ａに接続された各内部電極２は、外部電極４ａ→内部電極２ｂ→導電材料１１ａ→内部電極２ａ→導電材料１１ａという経路を経て上面の外部電極１４ａに接続されている。

【００１９】また、ポア１０ｂ内の導電材料１１（１１ｂ）及び中継電極として機能する内部電極２ｃを介して、最下層から２番目の内部電極２ｄが下面の外部電極１４ｂに導通するとともに、他方の側面（右側の側面）に引き出されて外部電極４ｂに接続された各内部電極２は、外部電極４ｂ→内部電極２ｄ→導電材料１１ｂ→内部電極２ｃ→導電材料１１ｂという経路を経て下面の外部電極１４ｂに接続されている。

【００２０】したがって、この実施例の積層型圧電体素子５においては、積層体３の側面に形成された外部電極４ａ，４ｂを、上・下面にまで回り込ませることなく、積層体３の側面に形成された外部電極４ａ，４ｂと内部電極２ａ，２ｂ，２ｃ，２ｄ，及び導電材料１１ａ，１１ｂを介して、各内部電極２と上・下面の外部電極１４ａ，１４ｂとを導通させることが可能になる。

【００２１】それゆえ、従来の積層型圧電体素子のように、積層体の側面に形成された外部電極を、上・下面にまで回り込ませた場合に見られるような角部における外部電極（厚膜電極）の盛上り（こぶ）の発生を防止して、積層型圧電体素子５の上・下面の平坦性を確保しつつ、内部電極２と上・下面の外部電極１４ａ，１４ｂとを確実に導通させることが可能になる。なお、上記実施例の積層型圧電体素子５においては、内部電極２と上・下面の外部電極１４ａ，１４ｂとを１０Ω以下の抵抗で導通させることができる。

【００２２】次に、上記実施例の積層型圧電体素子の製造方法について説明する。上記積層型圧電体素子を製造するにあたっては、通常の積層型圧電体素子の製造方法と同様に、まず、圧電体層（グリーンシート）を製造するために、原料を秤量し、粉砕してバインダとともに混合し、脱泡した後、シート状に成形し、所定の形状に打抜く。それから、これに内部電極を印刷する。

【００２３】なお、ポアを形成することを意図しない圧電体層のグリーンシートについては脱泡処理を施す（グリーンシートにポアが生じると隣接するグリーンシート間で短絡が生じるため、通常のグリーンシートには脱泡処理が施される）一方、ポアを形成すべき圧電体層のグリーンシートに対しては脱泡処理を施さないことによってポアを形成する。なお、単に脱泡処理を施さないだけではなく、積極的に気泡を混入させる処理（撹拌など）を施すことにより、所定の圧電体層のグリーンシートにポアを形成するようにしてもよい。

【００２４】それから、グリーンシートに電極材料（例えば導電ペースト）を所定のパターンで印刷し、各圧電体層（グリーンシート）を積層圧着した後、所定の焼成温度で焼成することにより積層体を得る。この積層体においては、圧電体層間に所定のパターンの内部電極が配設されているとともに、ポアの形成された所定の圧電体層においては、そのポア内に導電材料が浸透して導電性を有するに至っている。

【００２５】次に、得られた積層体の上・下面をラップし、内部電極が引き出された側面及び上・下面に外部電極を形成する（このとき、上・下面の外部電極が積層体

の角部にまで達しないようにする）ことにより、図１に示すような積層型圧電体素子５が得られる。

【００２６】そして、この積層型圧電体素子５は上・下面が平坦であるため、図２に示すように、複数の積層型圧電体素子５を金属板６を介して積み重ね、ばね圧などの機械的な力により固定することによって積層型圧電アクチュエータを形成する場合、積層型圧電体素子５を安定して積み重ねることができるため、複数の積層型圧電体素子５を確実に連結固定して信頼性の高い積層型圧電アクチュエータを得ることができる。

【００２７】また、図３に示すように、積層型圧電体素子５の上・下面に、互に異なる側面に引き出された各内部電極２が導通する２つの外部電極１４ａ，１５ａと１４ｂ，１５ｂを形成し（但し、最上層及び最下層の圧電体層１（１ａ），１（１ｃ）の上記外部電極１４ａ，１４ｂ，１５ａ，１５ｂが形成された部分にはポア１２ａ，及び１２ｂが形成され、その内部には導電材料１３ａ，１３ｂが浸透させられている）、接合面において互に対向する外部電極１４ａと１４ｂ、及び１５ａと１５ｂを直接に接続させるとともに、各積層型圧電体素子５を接着剤９により接着することにより、金属板を配設したり、あるいは、リード線を半田付けして側面に形成された外部電極を接続したりすることを不要にし、積層型圧電アクチュエータの構造及び製造方法を簡略化することが可能になる。

【００２８】なお、上記実施例では、上・下面の外部電極が形成される最上層とその次の圧電体層、及び最下層とその次の圧電体層にポアを形成し、その内部に導電材料を浸透させて導電性を付与した場合（図１）と、最上層と最下層の圧電体層にのみポアを形成し、その内部に導電材料を浸透させて導電性を付与した場合（図３）について説明したが、この発明において、選択的にポアを形成し、その内部に導電材料を浸透させて導電性を付与すべき圧電体層はこれらに限られるものではなく、必要に応じて上・下面の外部電極に近い複数の圧電体層に導電材料を浸透せしめて導電性を付与するように構成することも可能である。なお、その場合には、より導通性を得やすくするために、ポアの形成された各グリーンシートに電極材料を印刷することが好ましい。

【００２９】なお、この発明は、その他の点においても上記実施例に限定されるものではなく、圧電体層を構成する材料の種類や組成、あるいは圧電体層の具体的な形状や積層数、ポアに浸透させるべき導電材料の種類、内部電極及び外部電極の構成材料やそのパターンなどに関し、発明の要旨の範囲内において、種々の応用、変形を加えることができる。

【００３０】

【発明の効果】上述のように、この発明の積層型圧電体素子の内部電極と外部電極の接続構造は、上・下面の外部電極に近い圧電体層にポアを形成するとともに、その内部に導電材料を浸透させ、該導電材料及び側面に形成された外部電極を介して、各内部電極と上・下面の外部電極とを導通させるようにしているので、従来の積層型圧電体素子のように、外部電極を側面から上・下面にまで回り込ませて形成する必要がなくなり、上・下面の平坦性を確保しつつ、上・下面に形成された外部電極と圧電体層間に配設された内部電極とを確実に接続することが可能になる。

【００３１】したがって、複数の積層型圧電体素子を積み重ねて積層型圧電アクチュエータを構成する場合に、積層型圧電体素子の積重ね（連結固定）の安定性に優れ、かつ外力によって破壊したりすることがなく、信頼性の高い積層型圧電アクチュエータを得ることが可能になる。

【図面の簡単な説明】

【図１】この発明の一実施例にかかる積層型圧電体素子を示す断面図である。

【図２】この発明の一実施例にかかる積層型圧電体素子を積み重ねて構成した積層型圧電アクチュエータの要部を示す断面図である。

【図３】この発明の一実施例にかかる積層型圧電体素子を積み重ねて構成した他の積層型圧電アクチュエータの要部を示す断面図である。

【図４】従来の積層型圧電アクチュエータを示す断面図である。

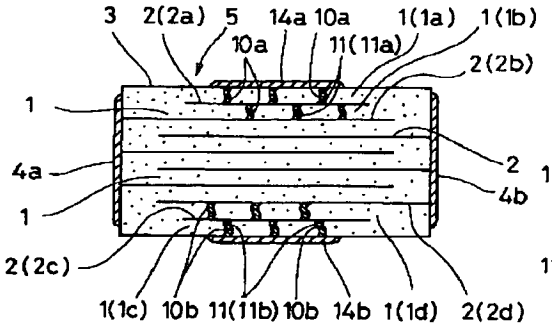
【図５】従来の積層型圧電アクチュエータを構成する積層型圧電体素子の内部電極のパターンを示す分解斜視図である。

【図６】従来の積層型圧電アクチュエータの要部を示す断面図である。

【符号の説明】

１	圧電体層
２	内部電極
３	積層体
４ａ，４ｂ	側面に形成された外部電極
５	積層型圧電体素子
６	金属板
９	接着剤
１０ａ，１０ｂ，１２ａ，１２ｂ	ポア
１１ａ，１１ｂ，１３ａ，１３ｂ	導電材料
１４ａ，１４ｂ，１５ａ，１５ｂ	上・下面に形成された外部電極

【図１】



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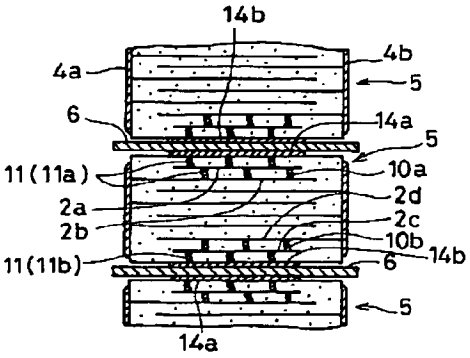
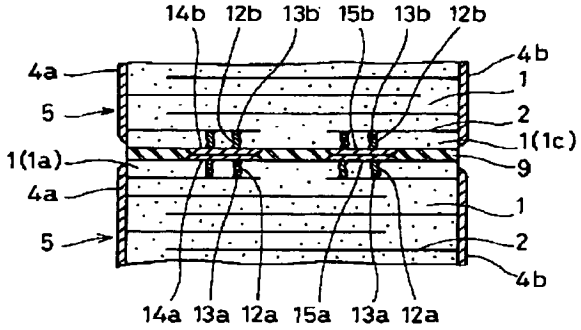


【図３】



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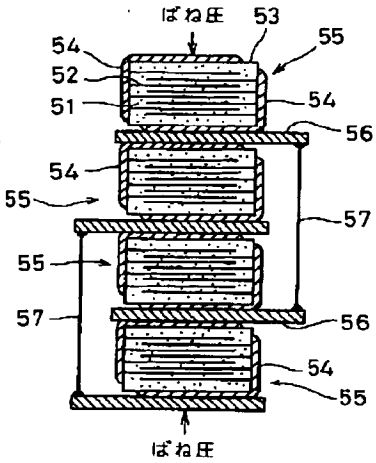

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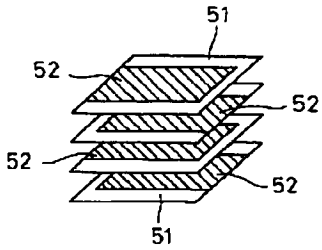
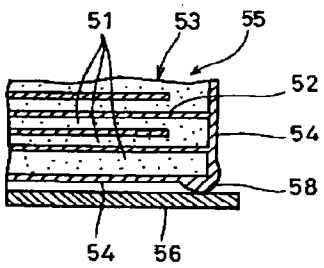


【図６】



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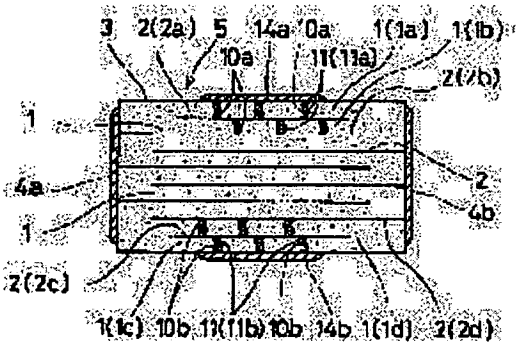
(54) CONNECTION STRUCTURE OF INTERNAL AND EXTERNAL ELECTRODES OF LAMINATION-TYPE PIEZOELECTRIC BODY ELEMENT

(57)Abstract:
PURPOSE: To positively connect an external electrode which is formed on upper and lower surfaces and an internal electrode provided between piezoelectric body layers without losing the flatness of the upper and lower surfaces of a lamination-type piezoelectric body element.
CONSTITUTION: Pores 10a and 10b are formed at piezoelectric body layers 1a, 1b, 1c, and 1d near external electrodes 14a and 14b on upper and lower surfaces and at the same time conductive materials 11a and 11b are impregnated inside them and then each internal electrode 2 and external electrodes 14a and 14b on the upper and lower surfaces continue via the conductive materials 11a and 11b and external electrodes 4a and 4b formed on a side surface.



LEGAL STATUS

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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] Two or more piezo electric crystal layers An internal electrode arranged between piezo electric crystal layers An external electrode formed in the side in which an internal electrode was pulled out, and a top and an underside It is the connection structure of an internal electrode of a laminating mold piezo electric crystal element, and an external electrode equipped with the above, and while forming pore in a piezo electric crystal layer near an external electrode of a top and an underside, an electrical conducting material is made to permeate the interior, and it is characterized by making it make it flow through each internal electrode and an external electrode of a top and an underside through an external electrode formed in this electrical conducting material and the side.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the connection structure for connecting electrically in detail the external electrode formed in the top and the underside, and the internal electrode arranged between piezo electric crystal layers about a laminating mold piezo electric crystal element.
[0002]
[Description of the Prior Art] As a laminating mold electrostrictive actuator using a piezo electric crystal For example, as shown in drawing 4 , while arranging the internal electrode 52 which has partial electrode structure among two or more piezo electric crystal layers 51 The laminating mold piezo electric crystal element 55 which arranges the external electrode 54 and becomes so that it may turn to the top and an underside from the side in which the internal electrode 52 of the layered product 53 which consists of a piezo electric crystal layer 51 and an internal electrode 52 was pulled out While accumulating more than one through a metal plate 56 and connecting the predetermined metal plate 56 with lead wire 57, the laminating mold electrostrictive actuator of the structure fixed according to the spring pressure is proposed.
[0003] In addition, in the laminating mold piezo electric crystal element 55 which constitutes the above-mentioned laminating mold electrostrictive actuator, as shown in drawing 5 , the internal electrode 52 is pulled out by turns by the edge by the side of reverse so that it may flow with the external electrode 54 (drawing 4) of the side by the side of reverse to set further.
[0004] Moreover, as an external electrode 54, the thick-film electrode is used in consideration of the soundness of a flow with an internal electrode 52.
[0005] And in this laminating mold electrostrictive actuator, the external electrode 54 formed so that it might turn even to each metal plate [which was inserted between each laminating mold piezo electric crystal element 55] 56 and laminating mold piezo electric crystal element 55 top and an underside is only contacted, and there is the advantage in which a flow with an internal electrode 52 and a metal plate 56 is obtained.
[0006]
[Problem(s) to be Solved by the Invention] However, in the above-mentioned laminating mold electrostrictive actuator, since it is formed so that the external electrode 54 of the laminating mold piezo electric crystal element 55 may turn even to a top and an underside from the side of a layered product 53, as shown in drawing 6 , in the corner of a layered product 53, it rises to the external electrode 54 (wen), 58 occurs, and the surface smoothness of the laminating mold piezo electric crystal element 55 top and an underside is spoiled. Therefore, when two or more laminating mold piezo electric crystal elements 55 are accumulated through a metal plate 56, a condition (connection fixed condition) becomes instability in accumulation, and there is a trouble that it is certainly unfixable, or destruction arises according to external force when it is used as a laminating mold electrostrictive actuator.
[0007] This invention aims at offering the connection structure of the internal electrode of the laminating mold piezo electric crystal element which can connect certainly the external electrode formed in the top and the underside, and the internal electrode arranged between piezo electric crystal layers, and an external electrode, without solving the above-mentioned trouble and spoiling the surface smoothness of a laminating mold piezo electric crystal element top and an underside.
[0008]
[Means for Solving the Problem] In order to attain the above-mentioned object, connection structure of an internal electrode of a laminating mold piezo electric crystal element of this invention, and an external electrode The side in which two or more piezo electric crystal layers, an internal electrode arranged between piezo electric crystal layers, and an internal electrode were pulled out, And a laminating mold piezo electric crystal element which comes to have an

external electrode formed in a top and an underside, While being the connection structure for connecting said internal electrode at least to one side of an external electrode of said top and an underside and forming pore in a piezo electric crystal layer near an external electrode of a top and an underside An electrical conducting material is made to permeate the interior, and it is characterized by making it make it flow through each internal electrode and an external electrode of a top and an underside through an external electrode formed in this electrical conducting material and the side.

[0009] In addition, this invention includes not only when connecting an internal electrode to both external electrodes of a top and an underside, but connection structure in a case of connecting an internal electrode only to either of the external electrodes of a top and an underside.

[0010] In connection structure of an internal electrode of a laminating mold piezo electric crystal element of this invention, and an external electrode, as a method for forming pore in a predetermined piezo electric crystal layer selectively For example, while performing degassing processing to a green sheet of a piezo electric crystal layer which does not mean forming pore It is possible to use a method of forming pore by not performing degassing processing or performing processing in which air bubbles are made to mix positively to a green sheet of a piezo electric crystal layer which should form pore.

[0011] Moreover, a method of making an electrical conducting material permeating in pore of a piezo electric crystal layer etc. can be used by applying and calcinating conductive paste to a green sheet of a piezo electric crystal layer which formed pore in pore as mentioned above as a method which an electrical conducting material is made to permeate.

[0012] In addition, while forming pore in a predetermined piezo electric crystal layer selectively, it is not restricted to an above-mentioned method and a method of making an electrical conducting material permeating in pore can also use a method of further others.

[0013]

[Function] In the connection structure of the internal electrode of the laminating mold piezo electric crystal element of this invention, and an external electrode, while forming pore in the piezo electric crystal layer in the location near an external electrode selectively, conductivity is given to this piezo electric crystal layer by making an electrical conducting material permeate that interior. Therefore, it becomes possible to make it flow through each internal electrode and the external electrode of a top and an underside through the external electrode formed in the side, and the piezo electric crystal layer to which conductivity was given, without rotating the external electrode (it having flowed with each internal electrode) formed in the side even on the top and the underside like the conventional laminating mold piezo electric crystal element.

[0014] So, generating of climax (wen) of the external electrode (thick-film electrode) in the corner of a layered product which is seen when rotating the external electrode formed in the side of a layered product even on a top and the underside like the conventional laminating mold piezo electric crystal element is prevented. It becomes possible to make it flow through each internal electrode and the external electrode of a top and an underside certainly, securing the surface smoothness of a laminating mold piezo electric crystal element top and an underside.

[0015]

[Example] The place by which shows the example of this invention and it is characterized [that] hereafter is explained in more detail. Drawing 1 is the cross section showing the laminating mold piezo electric crystal element which connected the internal electrode and the external electrode according to the connection structure concerning one example of this invention.

[0016] Two or more piezo electric crystal layers 1 to which the laminating of this laminating mold piezo electric crystal element 5 was carried out (piezo electric crystal layer which consists of a titanic-acid lead zirconate system material), It has the external electrodes 4a and 4b formed in the side in which the internal electrode 2 of the layered product 3 which comes to have the internal electrode 2 arranged among two or more piezo electric crystal layers 1, and two or more piezo electric crystal layers 1 and internal electrodes 2 was pulled out, and the external electrodes 14a and 14b formed in the layered product 3 top and the underside, and is constituted.

[0017] And while Pores 10a and 10b are formed in the center section of the piezo electric crystal layer 1 (namely, the maximum upper layer 1 (1a), its following piezo electric crystal layer 1 (1b), the piezo electric crystal layer 1 (1c) of the lowest layer, and its following piezo electric crystal layer 1 (1d)) in the location near the external electrodes 14a and 14b of a top and an underside The electrical conducting material (electrode for a flow) 11 (11a, 11b) is arranged in the interior. In addition, in the laminating mold piezo electric crystal element 5 of this example, in the external electrodes 4a and 4b of the side, the internal electrodes 2 (2a) and 2 (2c) nearest to the external electrodes 14a and 14b of a top and an underside do not flow, but are arranged in the condition of having floated, and they are constituted so that it may function as a junction electrode.

[0018] And while 2nd internal electrode 2b flows with external electrode 14a on top from the maximum upper layer through internal electrode 2a which functions as the electrical conducting material 11 (11a) and junction electrode in pore 10a Each internal electrode 2 which was pulled out by one side (left-hand side side), and was connected to external electrode 4a is connected to external electrode 14a on top through the path external electrode 4a-> internal electrode 2b-> electrical conducting material 11a-> internal electrode 2a-> electrical conducting material 11a.
[0019] Moreover, while 2d of 2nd internal electrodes flows in external electrode 14b at the bottom from the lowest layer through internal electrode 2c which functions as the electrical conducting material 11 (11b) and junction electrode in pore 10b Each internal electrode 2 which was pulled out by the side (right-hand side side) of another side, and was connected to external electrode 4b is connected to external electrode 14b at the bottom through the path 2d -> electrical conducting material 11of external electrode 4b-> internal electrodes b-> internal electrode 2c-> electrical conducting material 11b.
[0020] Therefore, it sets for the laminating mold piezo electric crystal element 5 of this example. The external electrodes 4a and 4b formed in the side of a layered product 3, internal electrode 2a, 2b, 2c, 2d, and electrical conducting materials 11a and 11b are minded without rotating the external electrodes 4a and 4b formed in the side of a layered product 3 even on a top and the underside. It becomes possible to make it flow through each internal electrode 2 and the external electrodes 14a and 14b of a top and an underside.
[0021] So, generating of climax (wen) of the external electrode (thick-film electrode) in a corner which is seen when rotating the external electrode formed in the side of a layered product even on a top and the underside like the conventional laminating mold piezo electric crystal element is prevented. It becomes possible to make it flow through an internal electrode 2 and the external electrodes 14a and 14b of a top and an underside certainly, securing the surface smoothness of the laminating mold piezo electric crystal element 5 top and an underside. In addition, it can be made to flow through an internal electrode 2 and the external electrodes 14a and 14b of a top and an underside in resistance of 10ohms or less in the laminating mold piezo electric crystal element 5 of the above-mentioned example.
[0022] Next, the manufacture method of the laminating mold piezo electric crystal element of the above-mentioned example is explained. In manufacturing the above-mentioned laminating mold piezo electric crystal element, like the manufacture method of the usual laminating mold piezo electric crystal element, first, in order to manufacture a piezo electric crystal layer (green sheet), weighing capacity of the raw material is carried out, and it is ground, and after mixing and carrying out degassing with a binder, it fabricates in the shape of a sheet, and pierces in a predetermined configuration. And an internal electrode is printed to this.
[0023] In addition, about the green sheet of the piezo electric crystal layer which does not mean forming pore, pore is formed by not performing degassing processing to the green sheet of the piezo electric crystal layer which should form pore on the other hand which performs degassing processing (degassing processing is performed to the usual green sheet since a short circuit arises between the green sheets which adjoin if pore arises in a green sheet). In addition, you may make it form pore in the green sheet of a predetermined piezo electric crystal layer by it not only not to performing degassing processing, but performing processings (stirring etc.) in which air bubbles are made to mix positively.
[0024] And after printing an electrode material (for example, conductive paste) by the predetermined pattern to a green sheet and carrying out laminating sticking by pressure of each piezo electric crystal layer (green sheet), a layered product is obtained by calcinating with a predetermined burning temperature. In this layered product, while the internal electrode of a predetermined pattern is arranged between piezo electric crystal layers, in the predetermined piezo electric crystal layer in which pore was formed, an electrical conducting material permeates in that pore, and it has come to have conductivity.
[0025] Next, the lap of the obtained layered product top and the underside is carried out, and the laminating mold piezo electric crystal element 5 as shown in drawing 1 is obtained by what (it is made for the external electrode of a top and an underside not to reach even the corner of a layered product at this time) an external electrode is formed in the side in which the internal electrode was pulled out, and a top and an underside, for.
[0026] And since this laminating mold piezo electric crystal element 5 has the flat top and underside, as shown in drawing 2 Since two or more laminating mold piezo electric crystal elements 5 are accumulated through a metal plate 6, it is stabilized and the laminating mold piezo electric crystal element 5 can be accumulated, when forming a laminating mold electrostrictive actuator by fixing according to mechanical force, such as a spring pressure, Connection immobilization of two or more laminating mold piezo electric crystal elements 5 can be carried out certainly, and a reliable laminating mold electrostrictive actuator can be obtained.
[0027] Moreover, as shown in drawing 3 , two external electrodes 14a and 15a through which each internal electrode 2 pulled out by the side which is different in ** flows, and 14b and 15b are formed in the laminating mold piezo electric crystal element 5 top and an underside. (However, Pores 12a and 12b are formed in the portion in which the above-

mentioned external electrodes 14a, 14b, 15a, and 15b of the piezo electric crystal layers 1 (1a) and 1 (1c) of the maximum upper layer and the lowest layer were formed.) While connecting directly the external electrodes 14a and 14b which counter ** in the plane of composition where electrical conducting materials 13a and 13b are made to permeate the interior, and 15a and 15b By pasting up each laminating mold piezo electric crystal element 5 with adhesives 9, it makes it unnecessary to arrange a metal plate or to connect the external electrode which soldered lead wire and was formed in the side, and it becomes possible to simplify the structure and the manufacture method of a laminating mold electrostrictive actuator.

[0028] In addition, when formed pore in the maximum upper layer in which the external electrode of a top and an underside is formed, its following piezo electric crystal layer, and the lowest layer and its following piezo electric crystal layer in the above-mentioned example, the electrical conducting material was made to permeate the interior and conductivity is given (drawing 1), Although the case (drawing 3) where formed pore only in the piezo electric crystal layer of the maximum upper layer and the lowest layer, made the electrical conducting material permeate the interior, and conductivity was given was explained The piezo electric crystal layer which form pore selectively, and an electrical conducting material is made to permeate that interior in this invention, and should give conductivity is not what is restricted to these. It is also possible to constitute so that an electrical conducting material may be made to permeate two or more piezo electric crystal layers near the external electrode of a top and an underside if needed and conductivity may be given. In addition, in that case, in order to make conductivity easier to obtain, it is desirable to print an electrode material to each green sheet with which pore was formed.

[0029] in addition , this invention be limit to the above-mentioned example in other points , and can add various application and deformation within the limits of the summary of invention about the component of the class of electrical conducting material which should be make to permeate the class of material which constitute a piezo electric crystal layer , a presentation or the concrete configuration and the concrete number of laminatings of a piezo electric crystal layer , and pore , an internal electrode , and an external electrode , its pattern , etc.

[0030]

[Effect of the Invention] As mentioned above, the connection structure of the internal electrode of the laminating mold piezo electric crystal element of this invention, and an external electrode Since he is trying to make it flow through each internal electrode and the external electrode of a top and an underside through the external electrode which the electrical conducting material was made to permeate the interior, and was formed in this electrical conducting material and the side while forming pore in the piezo electric crystal layer near the external electrode of a top and an underside It becomes possible to connect certainly the external electrode formed in the top and the underside, and the internal electrode arranged between piezo electric crystal layers, rotating an external electrode even on a top and the underside from the side, and it becoming unnecessary to form like the conventional laminating mold piezo electric crystal element, and securing the surface smoothness of a top and an underside.

[0031] Therefore, when two or more laminating mold piezo electric crystal elements are accumulated and it constitutes a laminating mold electrostrictive actuator, it becomes possible to excel in the stability of (connection immobilization) in accumulation of a laminating mold piezo electric crystal element, and not to destroy according to external force, and to obtain a reliable laminating mold electrostrictive actuator.

[Translation done.]

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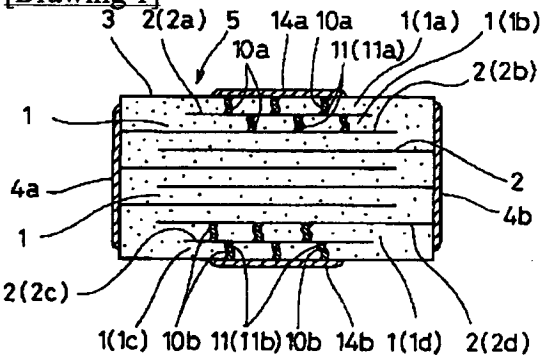
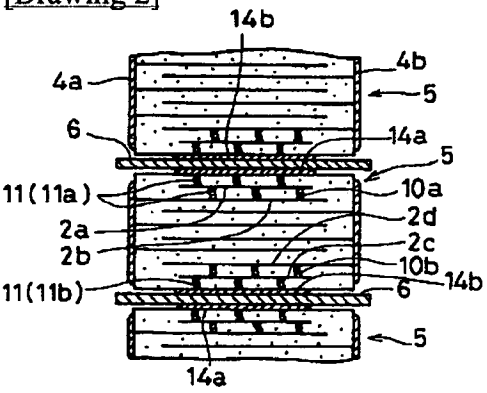
DRAWINGS

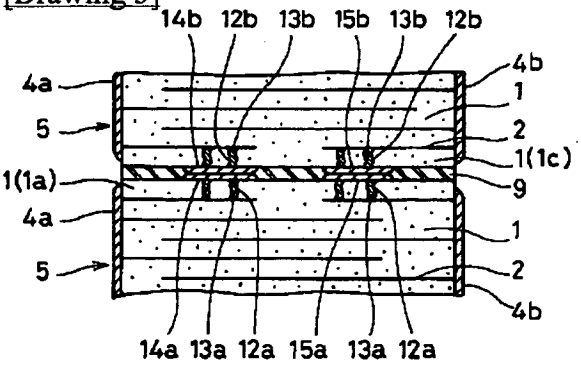
[Drawing 1]



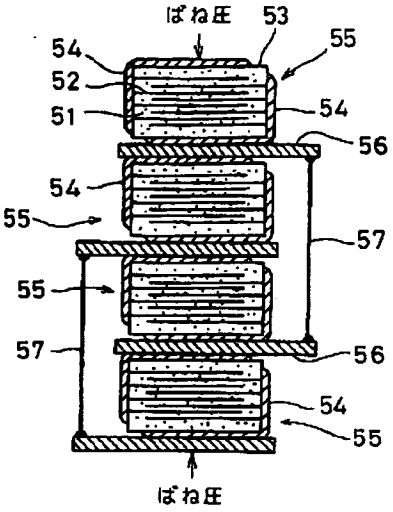
[Drawing 2]



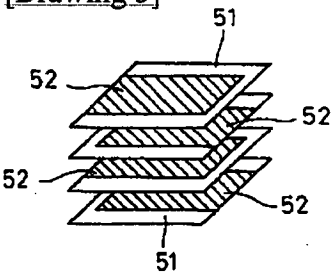
[Drawing 3]



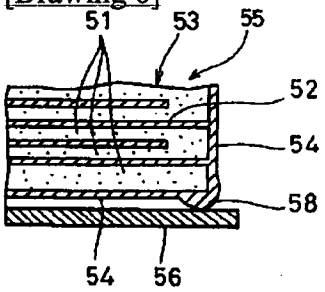
[Drawing 4]



[Drawing 5]



[Drawing 6]



[Translation done.]